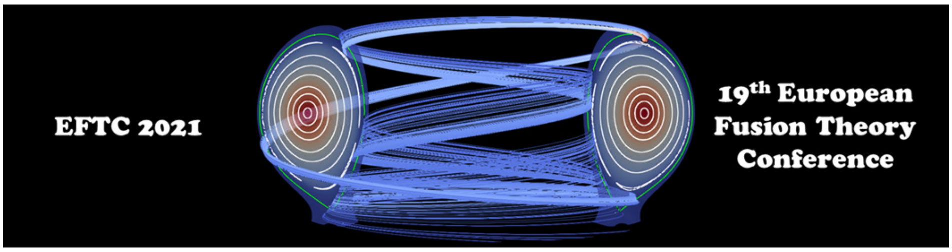

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Sparse Basis Polynomial Chaos Analysis of Radio Frequency Wave Scattering by Random Density Interfaces in the Fusion-Plasma Edge

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In a tokamak, radio frequency (RF) electromagnetic waves that propagate through low density plasma (n_l) enter the strongly turbulent edge region (n_e) before passing into the fusion plasma (n_p). Whether used for diagnostics or for heating and current drive, it is important to quantify the spectral properties of these waves. The magnetized n_l, n_p and n_e (via homogenization) regions are defined through the cold plasma, anisotropic permittivity tensor. Experimental evidence suggest that drift waves and rippling modes are present in the n_e region. Thus it is assumed that the n_e region is separated from the n_l and n_p regions by periodic density interfaces (plasma gratings) formed as a superposition of spatial modes with varying periodicity and random amplitudes. The ScaRF full-wave, 3D electromagnetic code has been developed for analyzing scattering scenarios of this form. ScaRF can be used for scattering analysis of any cold plasma RF wave and consequently for the scattering of electron cyclotron waves in ITER-type and medium-sized tokamaks. Since the density interfaces are random, the power reflection coefficient (R), obtained by ScaRF, is a random variable and is calculated for different realizations of the density interface. In this work, the uncertainty of R is rigorously quantified by use of the Polynomial Chaos Expansion method using Sparse Basis (SB-PCE) and Hyperbolic truncation schemes. The SB-PCE method is proven accurate, faster that other methods, and much more efficient, requiring only 11 R samples compared to thousands used by reference methods such as the Monte Carlo (MC) approach.

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